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ABSTRACT

This paper presents the results of an experiment using videoconferencing in a distance graduate course in the Computer Science Department at the Catholic University of Rio de Janeiro (Brazil). The purpose of the experiment was to test two videoconference technologies that are widely used on the Internet, Cu-SeeMe and Real technology, and to assess their performance and impact on a distance course. Objectives of the three stages of the experiment were: (1) to transmit the lectures live so that they could be watched at a distance simultaneously with the course site; (2) to transmit the lectures live and to record them for later use by the students; and (3) to make recorded lectures available so that students could watch them asynchronously. Results were assessed for later use in AulaNet, an environment for World Wide Web-based learning. CU-SeeMe proved to be suitable for synchronous events where interaction is necessary between participants. Real technology proved to be suitable for broadcasting information where interaction is not necessary, as it provides good quality audio and video, low transmission rates, and good continuity in the audio. Three figures present Cu-SeeMe windows, a remote student's screen showing CU-SeeMe and Real windows, and a page form the course Web site. (AEF)

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Rio Internet TV - AulaNet™
Using Videoconference in Web-Based Learning

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Abstract: This paper presents the results of an experiment using videoconference as a teaching resource in distance courses. CU-SeeMe and Real technology were tested for transmitting lessons live and recording lessons for asynchronous attendance. The results were assessed for later use in AulaNet™—an environment for web-based learning.

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1. Introduction

Education is gradually drifting towards the use of computer technology more and more, in particular the World Wide Web. The possibilities for web technology in education only began to be seriously explored at the end of 1996, when the term web-based education became more widespread. International Data Corporation [IDC 97)] believes that the enormous growth of web-based education and training, either through corporate intranets or the Internet that took place in 1997 is just the beginning, and that it will explode into a 2 billion dollar market in the year 2000. The main driving force for web-based training is the necessity to discover ways of bringing training directly to the desktop in a continuous just-in-time way—in order to train people with new abilities or knowledge.

The growing tendency of the traditional media to use digital technology plus the increasing amount of people who use computers in their professional and domestic environments is gradually transforming the way information is consumed [Tapscott 98] and creating a new culture of digital communication. The traditional learning process in a confined space like a classroom where the teacher appears at a set time and place and broadcasts information to a group of students is currently being questioned [Romiszowsky 97].

AulaNet™ <http://www.les.inf.puc-rio.br/aulanet/> is a software environment based on the World Wide Web being developed in the Software Engineering Laboratory (LES) of the Computer Science Department at the Catholic University of Rio de Janeiro (PUC-Rio) to create, give and attend distance courses. AulaNet™ [Lucena et all 97] was conceived as a result of the experience gained from three specific courses given at PUC-Rio during the second semester of 1997.

One basic element of the learning process is interaction between the various participants of a course, whether between instructor and students, or the students themselves, etc. One technology that can be used to facilitate this interaction is videoconference.

Rio Internet TV <http://www.inf.puc-rio.br/~refletor/> is a research nucleus within LES at PUC-Rio. One of its main objects of study is the use of videoconference as a tool for cooperation in groupwork [Laufer & Fuks 97].

In this work we present an experiment that was undertaken during the second semester of 1997 by Rio Internet TV using as a base a graduate course given in this department. The course, entitled Information Society <http://www.les.inf.puc-rio.br/socinfo>, was given by Professor Carlos J. P. Lucena and dealt with the impact of information technologies—a symbiosis between computing and communication—on society. To a large degree this impact is already visible in contemporary society and could produce a new type of society in the future that is already being called the "Information Society". The purpose of the experiment was to test current technologies, i.e. audio, video and text, through the Internet and to assess their performance and impact on a distance course.

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This document is structured in the following way: section 2 presents videoconference concepts and the technologies used in the experiment; section 3 presents the experiment; section 4 has an assessment of the results of the experiment and finally in section 5 the conclusion and future work are presented.

2. Videoconference and the Technologies used in the Experiment

Videoconference technologies have been in a process of evolution since 1964 when AT&T launched the first system - the Picturephone - at the World Fair in New York. In the beginning only proprietary technologies existed. Since then these technologies have been evolving in a way that has made them less expensive and more flexible, so that they can be used on a greater number of platforms.
Only recently has the use of videoconference technologies on the Internet been studied with greater attention. The technologies that compress audio and video are reducing the amount of information to be transmitted through the networks, at the same time that the width of the band which transmits the data is tending to grow, and will continue to do so in the next few years. Initially, due to the expensive equipment and running costs, videoconference was mainly used by large companies to hold meetings with their executives spread around the world in branch offices. Nowadays, there are a large number of softwares available on the Internet that offer the possibility of communication through audio and video at a low cost [Schindler 97].
The experiment conducted involved two videoconference technologies that are widely used on the Internet.
The first technology used to transmit lectures was CU-SeeMe, initially developed by Cornell University in the United States. The CU-SeeMe reflector is a server that enables many participants to connect to a videoconference. By connecting through a client—which could be White Pine Software's commercial version <http://www.wpine.com> or Cornell University's academic version <http://cu-seeme.cornell.edu>—it is possible to connect to a CU-SeeMe reflector and take part in a multimedia conference with audio, video and text.
CU-SeeMe is suitable for transmissions that need interaction, like for example, question and answer sessions, consultations etc. For the purpose of this experiment we used PUC-Rio's reflector—Rio Internet TV—the first public reflector in Brazil, that appears in lists all over the world, including the phone book distributed by White Pine. It began operating in 1994 and receives hundreds of visitors every day (more than 500), and has a Web site that serves as a source of information for the CU-SeeMe community in Brazil <http://www.inf.puc-rio.br/~refletor>. The Rio Internet TV reflector is for public use, it functions 24 hours a day and there is a videoconference room available (room 0) that can accept the participation of up to 30 people.
The other technology tested during the Information Society course was the one developed by Real Networks <http://www.real.com>, that broadcasts and records audio and image. This technology also uses the client/server architecture. The Real server is responsible for supplying audio and video streams compressed by a proprietary algorithm. The client side consumes the streams through a specific software—Realplayer—or as a plugin in a browser, thus enabling the image and audio to be presented on a Web page. Real technology transmits video streams that are consumed by the client side, therefore it is not necessary to wait for the the files to be completely transferred. The advantage of this technology is that it buffers the audio on the client's side in order to guarantee continuity in the sound, which is critical for the information to be understood.
As well as transmitting and recording lectures live, Real technology can also transmit files containing audio and video streams in a specific format, compressed at a high rate, through the Internet. Thus, lectures that have previously been recorded may be transmitted upon request through the network, as can any video edited through other technologies and converted to the Real format. However, Real technology does not yet offer the possibility of interaction between the participants of a videoconference.

3. The Experiment

The experiment was divided into stages and phases so that a step by step assessment could be made of the technologies used. They are explained in detail in the following paragraphs.

3.1 Stage 1

The objective of the first stage was to transmit the lecture live so that it could be watched at a distance together with the course site. The aforementioned Reflector was used to carry out this stage. A special

classroom (Room 10) was created in the reflector and only the machine installed in the classroom had permission to send audio and video. The other participants could only communicate via chat.
A Pentium 100 with 40 Mb RAM running Windows 95 was used to transmit the lectures. The camera used was a Colour QuickCam <http://www.connectix.com>, that dispenses the use of a video capture card. This camera is directly connected to the computer's parallel port and all the image processing is carried out by software. A four channel table with two microphones connected to it was used to capture the sound. The professor used a lapel mike to transmit the lecture and another microphone was made available for the students to ask questions at the end of the lecture. The same machine used for transmission was also used to show the slides, running Microsoft's Power Point software.
This first stage was divided into three phases. In the first phase the Reflector's public room remained open to the public and the transmission rate was 80 kbps.
In the second phase the Reflector's public room was closed for the sending of audio and video which noticeably improved the quality of audio and video received by the students. Some students even sent us sections of audio recorded by them from various locations proving the good reception of the audio.

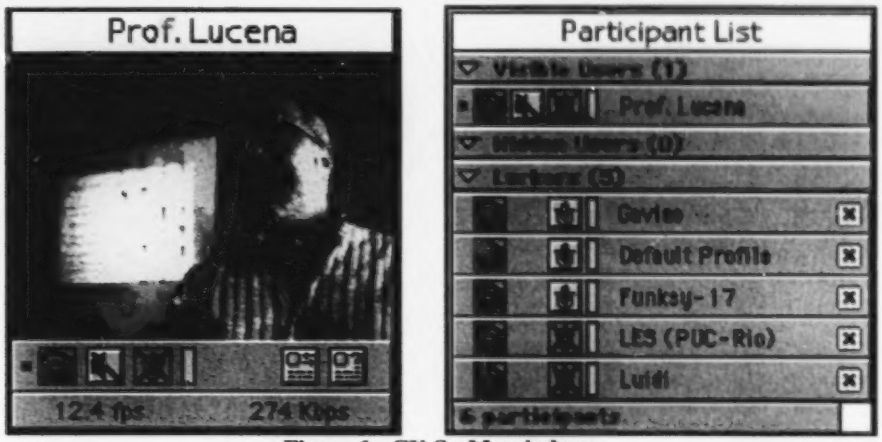

Figura 1 - CU-SeeMe windows

The presentation format of the lectures was similar to that used for giving speeches. Only when the instructor had finished speaking were the students allowed to ask questions. This strategy aimed to minimize interaction during the lecture. As there was only one microphone for the students present in the classroom and they were not accustomed to this type of lecture transmitted live, some of the discussions were lost, as the students did not remember to speak directly into the microphone. Thus, the more rigid structure of a speech followed by questions was opted for. At the end of the lectures, the students physically present in the classroom asked questions through the microphone while the remote students asked questions through a CU-SeeMe chat window. The questions sent by remote students were received by the instructor's assistant and read out loud through the microphone in the audience. Therefore, it was as if a student physically present in the classroom was asking the question.
In the third phase the transmission rate was raised to 300 kbps and a Pentium 200 with 64 Mb RAM running Windows NT was used exclusively for transmission via CU-SeeMe.

3.2 Stage 2

The object of the second stage of the experiment was to transmit the lectures live and to record them for later use by the students. As well as being transmitted by the Reflector, the lectures began to be transmitted and recorded via Real technology. In order to do this a Real live encoder was used to code the lectures while they were being transmitted to the server.
This stage was divided into three phases. In the first, only the audio was transmitted by Real technology using a Pentium 100. The Pentium 200 continued transmitting the lecture through CU-SeeMe—audio, video and chat.

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The second phase involved recording the audio through Real technology. Transmitting and recording the audio through Real demanded greater processing capacity; so the Pentium 100 was replaced by a Pentium 200 as the processor compresses the audio signal generated during transmission. The rate used for audio transmission through Real was 6.5 kbps.
In the third phase the video was also recorded using Real technology. In order to record the video a much more powerful machine was needed than had previously been used in the experiment. The specified machine was a Dual Pentium Pro 200 with 128 Mb RAM, Windows NT, an Osphrey 100 video capture card and a Videolabs Flexcam Pro video camera with S-Video output instead of a QuickCam. The transmission rate of the audio and video together through Real was 20 kbps.

Figure 2 - A remote student's screen showing CU-SeeMe and Real windows

Figure 2 above shows how the screen looked for remote students following lectures during this phase. We can see the CU-SeeMe windows and the RealPlayer window with Professor Lucena's image.

3.3 Stage 3

The object of the third stage was to make the recorded lectures available so that the students could watch them asynchronously.
The course site was reformulated enabling the students to follow the video and audio of the lectures together with the slides presented by the instructor, through the use of a browser running on any platform. In order to do this Real plug-in must be installed in the browser. This plug-in could be downloaded from the course site as well as the installation guidelines.

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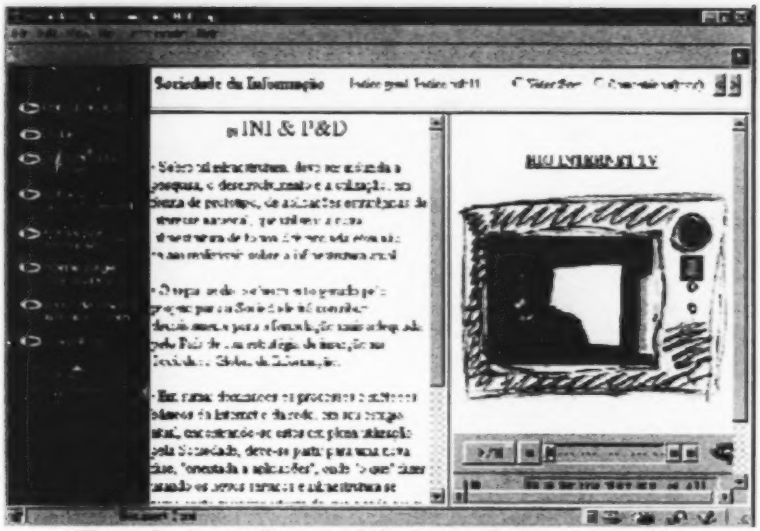

Figure 3 - A page from the Information Society course site.

Figure 3 above presents a page from the Information Society course site containing one frame with slides and another frame with the video of one of the lectures presented by Professor Lucena.

4. Assessment

Within PUC-Rio's internal network reception of the lectures through CU-SeeMe was very good, presenting continuous audio and well defined images. Outside PUC-Rio reception varied greatly depending on the participants' individual connection. The greatest problem was a discontinuity in audio because CU-SeeMe does not buffer the information transmitted.

It was observed that the audio transmitted by Real arrived with greater continuity despite the initial delay which was longer than that of CU-SeeMe. In figure 2 one can see a delay between the images shown in the CU-SeeMe window and those shown in the Real window. This delay is adjusted by Real's buffering mechanism, resulting in less information loss and greater continuity—which is critical for audio. Distance participants reported good reception of audio and video with some interruption in the audio, but as buffering does exist the information was received.

While the previously described experiments were taking place, we also undertook other activities with the purpose of better assessing how effective the distance lectures were. During the course another room was set up in another building on the campus, inside the same LAN, where some of the students could follow the lectures. In this environment, the speed of the network was approximately 2Mbps, much faster that than obtained by students watching the course through an ISP using a 28.8 kbps modem.

The group of students that watched the lectures in the second room at PUC-Rio (three groups of two students) told us that, to a certain degree, they achieved a greater level of concentration, because they had to pay more attention to the screen in order to follow the lecture. As this group of students had previously attended various lectures with Professor Lucena physically present, they were in a position to make a comparison between lectures with the instructor present and distance lectures. They also told us that as the classroom was dark due to the slide showing and full of equipment needed for the transmission, to a certain degree, it was less pleasant than the room in which they watched the lecture at a distance. Inside PUC-Rio the sound transmission was quite clear and enabled students to follow the lectures well.

One difficulty that the remote students encountered was slide changing. The slides for each lecture on the course were put on the course site. During the live lecture the remote students could receive the audio and video of Professor Lucena transmitted through CU-SeeMe and Real and followed the lesson through the slides put on the site. However, as there was no synchronization mechanism between the classroom browser and the distance browsers, the remote students did not know when the professor was changing the slides. This problem was minimized by one of the professor's assistants informing when the slides were changed through CU-

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SeeMe chat. During the course, the professor also adapted his presentation and began to indicate the slide he was currently talking about in order to facilitate comprehension for the remote students.
Another difficulty encountered by the participants in this experiment was related to the technical part of the transmission and recording. Lighting and camera positioning, to name but two examples, can make a big difference to the final result. Neither the professor, nor the staff in charge of the equipment had any experience in this type of activity. The professor gave the lectures normally directing himself to the people present, which is not necessarily the best way for the remote students. There are still limited resources for editing the recorded lectures. In a live lecture there are many interruptions that do not make sense in a recorded and edited version of a lecture. Unfortunately, at the moment, editing resources for Real files are quite precarious, which makes it difficult to take out the errors.

5. Conclusion and Future Work

The experiment in this work involved using two Internet videoconference technologies on a graduate course in the Computer Science Department at PUC-Rio.
CU-SeeMe technology proved to be suitable for synchronous events where interaction is necessary between participants, for example, group study meetings, and sessions between monitors and students to clarify doubts, etc.
Real technology proved to be suitable for broadcasting information, where interaction is not necessary, as it provides good quality audio and video, low transmission rates and good continuity in the audio, which in the majority of cases is the most critical part.
One matter that became quite clear through the experiment was that it is necessary for the instructor/presenter and the recording team to have more experience in this type of event. The transmission and recording of the audio and video demands skilled personnel. The instructor must have a posture suitable for appearing on camera, as well as a clear vocal pitch. Aspects that we consider to be mere details, like the color of the clothes worn by the instructor, may create important effects that only professionals have the capacity to give guidance on and make accurate assessments about. The video and audio must be interesting, not only from the point of view of content of the lectures, but also from the point of view of the media used. We are faced with a new form of consumption of information. Instructors will have to develop new abilities working together with communication professionals.
Lectures are gradually adopting a format that resembles entertainment. Students are inclined to a decentralized consumption of information as opposed to the classic model of confined education, whereby an instructor broadcasts information to a group at a determined time and in a determined physical space.
In future work we will conduct experiments with other videoconference technologies available for the Internet, like for example: Microsoft's NetShow or Real's RealFlash—that permits the inclusion of graphic resources in the videos—and White Pine's new software, ClassPoint, designed specifically for educational purposes.

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